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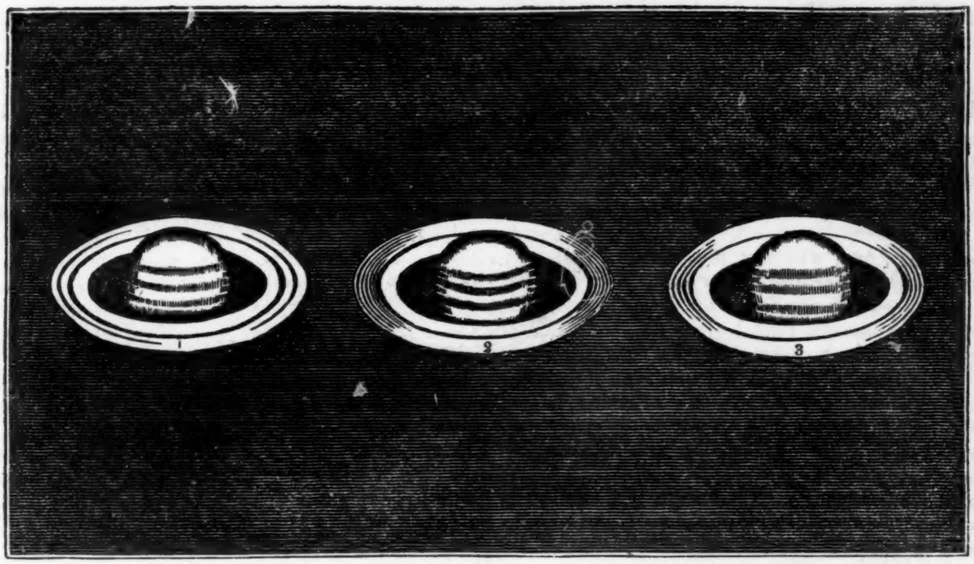
## POPULAR ASTRONOMY. PART V

Fig. 33.



THE RING OF THE PLANET SATURN, ACCORDING TO KATER'S OBSERVATIONS.

IN making observations upon the heavens, and the globes which exist and move about in them, the beholder, whether ordinary or telescopic, has his attention arrested at one time by the apparent size,—at another time by the brightness,—then again by the colour,—then by the sparkling,—then by the steady light of the celestial object of his vision:—these circumstances, one or more, are found to apply to the planets spoken of in our second paper, and likewise to the remaining planets, of which we are now about to speak. But most curious and singular above all, is the RING OF SATURN. To this nothing like or similar is found in the celestial creation; and so forcibly were we struck with this consideration, that we were led to assume this wonderful appearance, as our frontispiece, though, in order, it is the last but one of the planets to be treated of.

It astonishes us that a star should be found at all encompassed, and still more does it astonish us that there should be but one star, as far as our ken has enabled us to judge, which has so elegant, but mysterious, an ornament. Its nature and uses are matters of speculation, and easily occur, as warranted by fancy, to the mind of the reader of Astronomy; but when the reader finds that there is a planet beyond Saturn, which not only has no ring, but even a smaller number of moons than Saturn, he will feel himself puzzled to account for this seeming discrepancy in the regulation of the planetary globes by the Author of Good, unless he remember for a moment that full observations have not yet been made on the planet Herschel, or Uranus, owing to its immense distance, and the comparative imperfection of the instruments of man. To this we may append the consideration, that, by means inscrutable to us, the Almighty has in all probability compensated to other globes the deficiencies which their greater distance has occasioned them.

This consideration will apply likewise to the circumstance of no moon being found to revolve round the planet Mars, which is farther from the Sun than the Earth: but here, the constitution of its atmosphere is probably such, that so much solar light is absorbed and refracted, that lunar or reflected light is not found wanting. But we cannot afford to linger any longer in the regions of speculation; let us pass on therefore to consider

### THE EXTERIOR PLANETS.

THEIR wand'ring course, now high, now low, then hid,
Progressive, retrograde, or standing still,
In six thou seest.——MILTON'S *Par. Lost*, book. viii.

BEFORE we enter into the details of the planets, whose orbits are without that of the Earth, we have to notice a peculiarity in their motions, as seen from the Earth, which results from the circular or elliptical form of their orbits, combined with the annual motion of the Earth. We alluded to this at Vol. XIII., p. 124.

When a planet appears to move from the neighbourhood of any fixed stars, towards others which lie to the east, its motion is called *direct*, because the planets move round the Sun from west to east. When a planet seems to move towards the stars which lie westward, its motion is said to be *retrograde;* and, at other times, it appears to be *stationary*.

Now, as the planet is, in fact, constantly moving round the Sun, as its centre, it is said to have the three foregoing motions, which will be easily apprehended by the accompanying diagram (fig. 34).

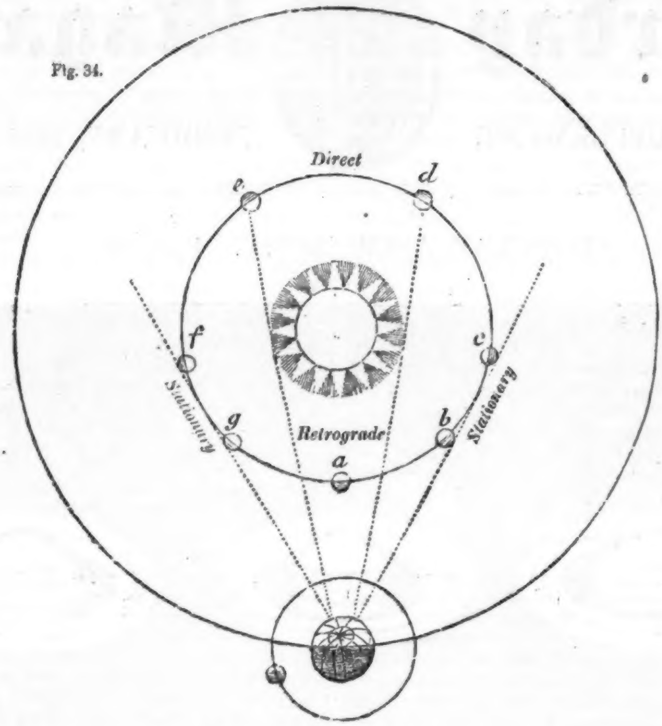
Suppose a planet to revolve round the Sun from west by south to east, according to the letters *a*, *b*, *c*, &c. When the planet is so situated, that a line from the centre of the Earth will graze that part of the orbit where the planet is situated, the planet's motion is said to be *stationary*, as at *b c* and *f g*. The planet is then approaching to, or receding from, the Earth. When the planet is farthest from the Earth, it has its natural or *direct* motion, as from *d* to *e*. But when the planet is nearest to the Earth, as at *a*, its motion is termed *retrograde*, because, owing to the motion of the Earth in the same direction, it seems to go back in its course.

### MARS.

See Mars, alone, runs his appointed race,
And measures out exact the destined space;
Nor nearer does he wind, nor farther stray,
But finds the point whence first he rolled away.

THIS is the nearest planet which is exterior to the Earth, and is remarkable for having a more ruddy colour than

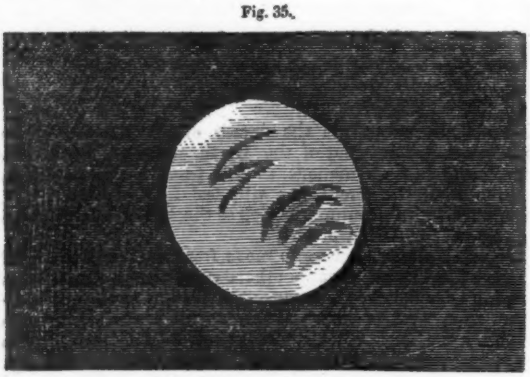
Fig. 34.




MOTIONS OF THE PLANETS.

most of the other planets. This ruddiness is believed to be due to a peculiar constitution of its atmosphere; whereby it absorbs all the component parts of the solar rays but the red, which it reflects.

Fig. 35.

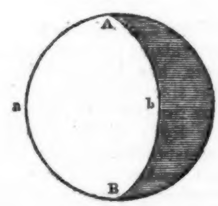


MARS IN THE GIBBOUS FORM.

The mean diameter of this planet is about 4189 miles, being rather more than half the diameter of the Earth. His form is that of an oblate spheroid, which is occasioned by his rotation on his axis, and is much more flattened than that of the Earth, his greater diameter being to his smaller as 16 to 15. He revolves round the Sun in an orbit which is, at the mean distance, about 144 millions of miles from the Sun: this orbit he travels round in about 687 of our days with a velocity of fifty-three thousand miles in an hour. We say *our* days, in order not to confound them with the day of Mars; for, as he rotates on his own axis in about 24 hours 39 minutes, his day is rather longer than ours, so that the period of his revolution is about 668 of his days. His rotation on his axis is estimated by permanent spots on his disk, which appear to be mountains as shown in the figure above.

There are some circumstances in the appearance of Mars which confirm the statement that his orbit is exterior to that of the Earth. The appearance which he commonly presents is gibbous. This phase may be illustrated by the following figure, A *a* B *b*. Here we see that A *a* B is a semicircle, and that A *b* B is part of an ellipse; these joined together form the *gibbous* phase. Thus Mars sometimes appears gibbous, (as shown in fig. 35,) but never crescent-formed; as he would if he revolved within the

Fig. 36.




Earth's orbit: he appears nearly five times as large at one time as he does at another, on account of his being so much nearer to the Earth when the Earth is between Mars and the Sun, than when the Sun is between Mars and the Earth. When at his farthest distance from the Earth he subtends an angle of 4″, and when at his greatest distance an angle of 18″, and the inclination of his orbit to the plane of the ecliptic is 1° 51′.

Fig. 37.

In Opposition. In Conjunction.

THE PLANET MARS.

This planet is about one-seventh of the size of the Earth, and is supposed to enjoy about half the light and heat that we have, but in a similar proportion throughout his year,

from the circumstance that his axis is inclined to the plane of the ecliptic, nearly at a like angle with the Earth's, though he is much farther off from the Sun.

The matter, of which this planet is composed, is about one-fourth lighter than that of the Earth. His rotation on his axis, as determined by the motion of certain spots on his surface, is found out in the same way as was before explained concerning the Sun. See Vol. XIII., p. 34.

No moon has ever been found to accompany this planet; though, being farther from the Sun than the Earth, it would seem to stand more in need of a luminous auxiliary. But, by means of a good telescope, the poles, or extremities of the rotating parts of this planet, are observed to present a white appearance, which becomes fainter when the pole, in the course of the planet's orbit, is turned to the Sun, and more decided when inclined away. These white spots are naturally enough considered to be polar snows, which disappear at the parts of the planet which have been for some time exposed to the Sun, while in the mean time they reappear at the other part; the former being the Summer, the latter the Winter, of Mars.

The axis of Mars is inclined to the ecliptic at an angle of about $30\frac{1}{4}$°. The Earth and Moon would appear like moons to Mars; but, being in an orbit between Mars and the Sun, would never appear quite full.

### THE ASTEROIDS.

UNTIL the present century, Jupiter was always considered to be the planet next in order of distance to Mars; but, since the commencement of this century, four little planets called *Asteroids*, because they had the *appearance of stars*, have been discovered, all of which are farther from the Sun than Mars, but less remote than Jupiter. These asteroids, or small planets, are called Vesta, Ceres, Pallas, and Juno, names of celebrated heathen deities of the feminine gender.

Vesta was discovered in 1807 by Dr. Olbers, an eminent German philosopher. It is supposed to be not more than 238 miles in diameter, though this is not yet considered as settled: its mean distance from the Sun is about 225 millions of miles, and it travels through its orbit round the Sun in about 1136 of our days: whether it revolves on its axis is not yet known, on account of its small dimensions. This planet was discovered last of the four, but is nearer to Mars than the others.

Ceres is about 295 millions of miles from the Sun, and is about 1760 miles in diameter: it takes about 1680 days to revolve in its orbit round the Sun. M. Piazzi, of Palermo, in Sicily, discovered this planet on the first day of this century; it appears like a star of the eighth magnitude, and has a ruddy colour.

Pallas is about as far as Ceres from the Sun, and goes round him in about four years and eight months. This planet is stated to be rather smaller than the Moon in size. It was discovered by Dr. Olbers in 1802.

Juno's distance from the Sun is about 301 millions of miles, and it revolves round the Sun in about four years and four months: the diameter has been stated at about 1500 miles. Its apparent size is similar to that of Ceres. It was discovered by M. Harding of Lilienthal, in 1804.

In speaking of these little planets, it is necessary for us to remark that any statements as to their diameters are not much to be depended upon: the extremely small diameters which they present to the eye deprive the astronomer of much of the groundwork on which he builds his calculations. In fact, not only are these planets not seen with the naked eye, but they cannot be observed at all, except with the very best instruments. It is well known that the appearance of the largest and brightest of them, as seen through the instruments at the Greenwich Observatory, is only similar to that of stars of the sixth magnitude; and, when any one of these planets is among stars of such magnitude, it is impossible to distinguish the planet from the stars; and it has often occurred that one of the fixed stars has been taken for the planet and observed for a good while in its stead.

In respect of the position of these little planets in the solar system, we may remark that there was formerly considered to be, as noticed at the end of this article, a wider interval than the proportions of the solar system allow between the orbits of Mars and Jupiter; so wide, indeed, that many astronomers had predicted that some new planet would, at one time or other, be discovered between them. Now it so happens that the four asteroids are very close together, and just at the distance from the Sun at which a new planet might be expected to lie: it is supposed, therefore, by some philosophers, that these four small planets are fragments of a larger planet which once moved in an orbit nearly coincident with the general position of these little planets. What mighty convulsion of Nature could have produced such a catastrophe, we can only conjecture: nothing for certain on such a subject can be known to us, except that "He who could make could also destroy."

It should be observed that the Sun's apparent motion is always in the ecliptic; or rather, this is the path of the Earth among the fixed stars, as it is seen from the Sun. The Moon and all the other planets move within the Zodiac, which is 16° broad; the ecliptic being a line dividing it into two equal parts. The distance of the Moon or of any planet from this line, northward or southward, is the *latitude* of such heavenly body. The latitude of the Moon and the six planets is never greater than 8°, so that they are always *within* the Zodiac; but the asteroids, having oftentimes a greater latitude than 8°, are termed *ultra*-zodiacal, their orbits not being confined within the Zodiac.

Many astronomers are, however, of opinion that the largest of these planets, Ceres and Juno, have not a diameter of more than one hundred miles, and that their average density is about twice that of water. Pallas is said to have a very hazy and extensive atmosphere.

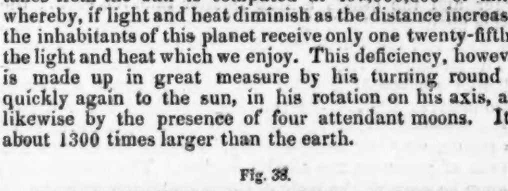
In respect of the orbits of Ceres and Pallas, it should be observed that, though the annual period of the latter is longer than of the former, and though, in mean distance, it is a superior and more remote planet, yet, owing to the greater eccentricity of its orbit, its circumference is smaller than that of Ceres. These orbits, therefore, intersect each other, and may eventually lead to a mutual disturbance between the two bodies in question, unless some extraneous circumstances, such as the attraction of the larger planets, operate to prevent it.

### JUPITER.

Beyond the sphere of Mars, in distant skies
Revolves the mighty magnitude of Jove,
With kingly state, the rival of the Sun.
About him round four planetary moons,
On earth with wonder all night long beheld
Moon above moon, his fair attendants, dance.

THIS is the greatest of all the planets, and consequently the brightest; except Venus, when she approaches near to the earth. Jupiter is an oblate spheroid, his greater diameter being more than 89,000 miles. Owing to his revolving so rapidly on his axis,—the diurnal rotation being completed in ten hours,—he is more flattened than any other planet; his greater diameter exceeding the smaller by 6000 miles,—more than three-quarters of the whole diameter of the earth. He moves round the sun in about 4332 days, which is nearly twelve years, by which his motion in his orbit is about 25,000 miles in an hour; while the motion of any spot on the protuberant part of his surface, due to the rotation on his axis, is about 26,000 miles an hour, which motion is more than twenty-five times as rapid as the rotatory motion of the earth. His mean distance from the sun is computed at 490,000,000 of miles, whereby, if light and heat diminish as the distance increases, the inhabitants of this planet receive only one twenty-fifth of the light and heat which we enjoy. This deficiency, however, is made up in great measure by his turning round so quickly again to the sun, in his rotation on his axis, and likewise by the presence of four attendant moons. It is about 1300 times larger than the earth.

Fig. 38.



TELESCOPIC APPEARANCES OF JUPITER.

The axis of Jupiter being perpendicular to the plane of his orbit, the seasons in this planet must remain constant, and the days and nights always of the same length.

This planet, like most of the others, appears larger in

opposition than in conjunction; it being nearer the earth in the former case than in the latter. In opposition he subtends an angle of 46″, and in conjunction an angle of 30″. His form, as seen through a good telescope, is oval; the equatorial diameter being to the polar as 13 to 12. The density of this planet is one twenty-fourth greater than that of water; but, nevertheless, owing to his vast bulk, it has a disturbing influence on the bodies of other planets, comets, &c., and the force of gravity at his surface is eight times that of the earth. His orbit is inclined to the ecliptic at an angle of abo· $1\frac{1}{4}$°.

When this planet is viewed through a telescope, he appears to be surrounded by several belts, as may be seen in the preceding figure, which are all parallel to one another: sometimes these belts are reduced to one or two in number, while at other times they amount to seven or eight; from which it has been conjectured that these belts are not existent on the body of the planet, but are caused by certain fluctuations in his atmosphere: sometimes they continue without manifesting any change for two or three months, while at other times they alter their appearance in the course of an h ur. Of these *zones*, or belts, the darker parts are supposed to be the body of the planet appearing through a luminous, but cloudy atmosphere.

One of the most remarkable circumstances connected with the planet Jupiter is, the existence of four little moons, which revolve round him in the same way that our moon revolves round the earth. The world owes the discovery of these satellites to Galileo:—they were the first fruits of the invention of the telescope, for which we are also indebted to him. Having perceived that a convex and a concave lens, placed in certain positions with respect to each other, gave an enlarged view of an object seen through them, he conceived the grand idea of applying such a combination to the exploration of the heavens, by which the limited power of the human eye could be augmented. He did so: he placed two such lenses in an organ-pipe, which served him as a tube; and thus he constructed the first telescope which the world ever saw*. On turning this telescope towards the planet Jupiter, he perceived a small star near him: and at different times afterwards he discovered three others, all near the planet: these little stars were found to revolve round the planet; for they would come in front of his illuminated surface, travel to one side, pass round behind him, and emerge on the other side, just as Venus and Mercury do round the Sun. He took them at first for *telescopic* stars, that is, stars seen only by means of the telescope. It was about the year 1610, when this discovery took place.

These satellites may be seen with a telescope which magnifies thirty times, or with a considerably lower power, if the atmosphere be very pure. They revolve round Jupiter in various times;—the first being one day, eighteen hours; the second three days, thirteen hours; the third seven days, three hours; and the fourth sixteen days, sixteen hours:—these numbers are approximations sufficient for our present purpose. Their distances from Jupiter are about as follow:—first, 260,000 miles; second, 420,000 miles; third, 650,000 miles; fourth, 1,150,000 miles. These planets are about the size of the earth, some being a little larger and the others a little smaller than the earth; the first is about one-third, the second three-fourths, the third one-half, and the fourth one-third of the earth's diameter.

The passage of these little satellites in front of the illuminated surface of Jupiter has been of great service to astronomers: first, in determining that light does not pass instantaneously from one place to another, however rapid its motion may be; and secondly, in laying down the longitude of places on the earth's surface. The satellites can seldom be seen on the body of the planet, even with the aid of a telescope, except just at the time of apparent contact; when the satellite, by being somewhat nearer to the sun,—the source of light to the whole system,—appears a little brighter than the planet behind it. They are, however, sometimes seen as darkish spots on the illuminated disk of Jupiter: this has been attributed to the existence of spots on the surfaces of the satellites, similar to those which we observe on the surface of our moon. This opinion is further supported by the fact that the same satellite will appear as a bright spot at one time, and as a dark one at another; probably on account of its exhibiting a different side to the earth at one time from that which it presents at another.

It is remarkable that all these little satellites resemble our moon, in the circumstance that they revolve on their axes, respectively, in the same time that they revolve round the primary planet Jupiter: this fact has been determined by the same means which enable astronomers to establish the like fact with respect to our moon, namely, the constant position of certain spots on their surfaces with regard to the situation of Jupiter, although these greatly vary as seen from the earth; a consequence of this fact is, that these moons always present the same sides towards Jupiter.

As the orbits of three of these are nearly coincident with the orbit of Jupiter, it follows that the Sun suffers an eclipse, as seen from Jupiter, whenever either of these moons is new, or between Jupiter and the Sun: this phenomenon can, by the aid of good telescopes, be seen from the earth, notwithstanding the immense distance which separates the earth from Jupiter: a faint shadow is seen to traverse the surface of Jupiter, occasioned by the passage of one of his satellites between him and the sun. The eclipses, which are, however, most distinctly visible from the earth, are those in which the satellites themselves are eclipsed, by passing into the shadow of Jupiter, behind the body of the planet: the very short period which they occupy in going round their primary planet, Jupiter, render these eclipses extremely frequent.

To an observer on the earth, there is perhaps no spectacle in the heavens more interesting. With a tolerably good telescope they may be seen distinctly, at one time all in the same straight line on one side of the planet; at another, part on one side and part on the other, but still in a straight line. If they be watched for a few hours they will be seen to change their relative positions; and after a while some or other of them will pass into the shadow behind Jupiter, and so they will become invisible; this is called an *immersion.* The act of coming out of the shadow is called an *emersion.* These are in fact eclipses, or occulations; and occur with great frequency on account of the quick revolutions of these moons round the planet. The same may be said of the transits of the moons over the disk of the planet.

The times of the immersions of Jupiter's satellites in the shadow of the planet, and of their emersion, as likewise of the transits of these bodies over the face of the planet, are given in calendars, devoted to astronomy, in order to furnish a means for knowing the longitude, or the difference of meridians, on the earth's surface. The times given in the Nautical Almanack, White's Ephemeris, &c., are adapted to the meridian of Greenwich: so that, if at any other meridian, an observer notice an immersion or an emersion of one of these satellites, or the beginning or end of its transit over Jupiter's disk, to take place one hour, for instance, sooner than the time specified for Greenwich, he knows that he is 15° west of Greenwich; because the sun, in passing round the earth, must make noon and other consequent periods of time sooner to the eastern parts of the world, than to the western; and as he passes over 15° of the earth's surface in one hour, by reason that the earth revolves once on its axis in twenty-four hours, it follows, that to a person situated 15° westward, it will be, for instance, only 11 o'clock, when it is noon at Greenwich. If the observer notice the fact as occurring one hour after the Greenwich time, he may be sure that he is 15° east of Greenwich.

Before Jupiter is in opposition, or so long as he passes the meridian in the morning, the shadow lies west of the planet: and the immersions happen on that side: but after the opposition, the emersions happen to the east.

This method of finding the longitude is more or less accurate according to the practice of the observers, the goodness of the instrument, and the correctness of the tables. The immersion and emersion of the first satellite,—that whose orbit is nearest to the body of the planet,—serves the purpose of the longitude most effectually; the motions of this planet being more clear and defined than of the others.

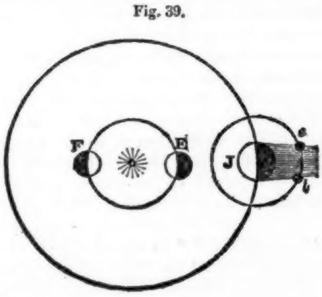
Observations respecting the *progressive* motion of light were first made by noticing these little attendants of Jupiter. It had been usual to consider that light was sudden and instantaneous in its effects. "But there is something so strange in the circumstance that light, as far as the evidence of the senses is concerned, should appear to occupy absolutely no time at all in travelling from place to place, that philosophers have applied many tests, by which they hoped to ascertain whether any portion of time could be estimated during its transit from one station to another. All means, however, failed till about the year 1675, when Römer, an eminent Danish philosopher, ascertained that

* See Tomlinson's *Manual of Natural Philosophy*, p. 500.

light occupies an appreciable, but still very small, portion of time in travelling from the Sun to the Earth. The circumstance which enabled him to determine this important fact was, that the eclipses or immersions of the four little moons, which revolve round the planet Jupiter, did not occur precisely at the periods which calculation had assigned for them; the variation being greater at one period of the year than at another period, six months before or after. From this circumstance he concluded that, when the apparent error was greatest, the light traversed a longer path in coming from those little moons to the earth; and that so the last gleam of light shed previously to a moon's disappearance behind the body of a planet, did not reach the eye until some time after the commencement of the immersion; hence, the retardation would of course be increased, as the distance of Jupiter from the Earth increased. Reasoning from these data, Römer came to the conclusion that the transference of light is *not* instantaneous; but that, like every known agent, it occupies a portion of time in traversing a certain space. Knowing the distances of the principal heavenly bodies from each other, and testing those distances by the apparent retardation of the eclipses of Jupiter's satellites, Römer computed that light traversed the distance from one point of the Earth's orbit to the opposite point, in about eleven minutes. Subsequent calculations, however, have proved this to take place in about sixteen and a half minutes, so that eight and a quarter minutes is the time employed by a ray of light in travelling from the Sun to the Earth; which, being a distance of about ninety-five millions of miles, gives, in round numbers, a velocity of nearly 200,000 miles in a second."—TOMLINSON'S *Manual of Natural Philosophy*, p. 395.

This subject may be well illustrated by reference to the following figure. If we suppose that Jupiter is, upon an average, about 500 millions of miles from the Sun, and the Earth about 100 millions of miles, then, if Jupiter be in conjunction, or the Sun be between Jupiter and the Earth, the Sun's rays must travel about 500 millions of miles to Jupiter or his Satellites, and then, after reflexion, about 600 millions of miles back to the Earth, or 1100 millions of miles altogether; whereas, if Jupiter be in opposition, or the Earth be between the Sun and this planet, the two journeys of the solar rays amount only to 900 millions of miles, which gives the difference, in point of time, first noticed by Römer.

Fig. 39.



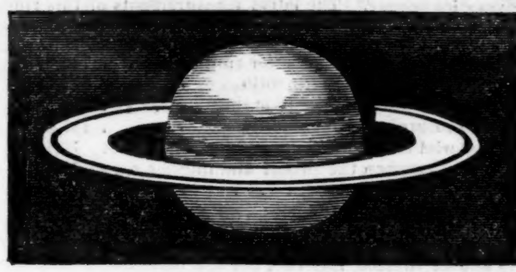

In the preceding figure, let J be Jupiter, *e* a satellite entering its shadow, and *i* a satellite emerging from it. When the Earth is at E, Jupiter is in opposition, but when the Earth is at F, the planet is in conjunction. In the former case, the solar rays have not so far to travel as in the latter.

### SATURN.

Last, outmost Saturn walks his frontier round,
The boundary of worlds, with his pale moons,
Faint glimm'ring through the gloom which night has thrown
Deep-dyed and dead, o'er this chill globe forlorn:
An endless desert, where extreme of cold
Eternal sits, as in his native seat,
In wintry hills of never-thawing ice.
Such *Saturn's* earth; and even here the sight,
Amid these doleful scenes, new matter finds
Of wonder and delight! a mighty *ring!*

THIS planet is distinguished from every other body in the Heavens, so far as discoveries have yet gone, in the circumstance of being surrounded by a flat luminous ring, extending to a considerable distance from the body of the planet, in a manner analogous to the wooden horizon of an artificial globe. Till within sixty years ago, it was considered to be the farthest of all the planets; as we found the poet speak of it above.

Fig. 40.



TELESCOPIC APPEARANCE OF SATURN.

Saturn revolves round the Sun in an orbit, the mean distance of which from the Sun is about 900 millions of miles, about 9½ times that of the Earth from the Sun: his diameter is about ten times, and his whole magnitude about 1000 times that of the Earth; and the Sun appears to him to have not above $\frac{1}{90}$th part of the disk, or area, which he presents to the Earth; consequently, the light and heat received by Saturn from the Sun are less than that received by the Earth in the same ratio. Some persons have computed it to be about 500 times as much as that which is afforded by our full moon; whereas our sunlight is estimated at 300,000 times that of our moonlight.

Saturn travels in his orbit about 21,000 miles an hour, and takes up nearly 30 years in passing once round the Sun. He revolves once on his axis in about 10¼ hours. The revolution on his axis produces the same effect as on other planets, namely, flattening him at the poles, and occasioning a protuberance at the equator; the two diameters have been stated as being about in the ratio of 2281 to 2061; it is however, remarkable that the greatest diameter is not at the equator, but at a point nearly mid-way between the equator and the poles—this gives to Saturn somewhat the appearance of a square with rounded corners, as may be observed in the figure above. This was one of the earliest subjects for discovery with the telescope. The density of this planet is about one half that of water. His orbit makes an angle of nearly 2½° with the ecliptic; that is, this planet may have that latitude: and his axis is inclined to his orbit at an angle of about 60°; which makes great variety of seasons though these be slow in coming round. His apparent diameter is, owing to his great distance, much the same at every part of his orbit, and subtends an angle of about 18″. He may be seen in the heavens without the aid of a telescope, if we know at what place to look for him. His disk is crossed by obscure zones, or belts, like those of Jupiter, which vary in their figure according to the direction of the rings.

When Galileo first presented his telescope towards Saturn, he perceived what appeared like two small bodies at the sides of the planet; and he thought at first that this planet was made up of three stars. It was soon found, however, that these lateral appendages changed their appearance, and assumed the form of a *ring* surrounding the planet. If we encircle a ball with a flat ring, and hold it in a particular position, the ring will appear as nothing more than a *line* across the ball; but, if we incline the latter a little, the ring will appear somewhat oval, or elliptical; and if we turn it round a quarter of a circle from its first position, the ring will appear as a *perfect circle.* Now the same thing occurs with regard to Saturn, except that we never see the ring as a *perfect* circle: it is sometimes a line, when the eye is in the plane of the ring; and at other times an ellipse, when the eye is inclined to that plane. The ring does not touch the planet; for a dark vacant space can be seen between them: indeed, the whole would appear dark, were it not that the Sun's light is reflected from it to the Earth: it does not shine by light reflected from the planet, but by that which is derived from the Sun; therefore there are some positions of the Sun, Earth, and Saturn, when the ring is invisible to us. The ring presents its edge towards the Earth every fifteen years, twice in the planet's revolution, but is seen as an elongated oval between those periods: in 1833 it presented its edge towards the Earth, and will do so again about 1848: at present the northern surface of the ring is visible to the Earth.

Sir W. Herschel made many careful observations on this ring, and found that it actually consists of *two* rings, one

within another, with a dark space between them; the ring was found to reflect a stronger light than the body of the planet, and to cast a shadow on the planet, thereby proving its opacity. The latest measurements of this ring are as follow:—

| | Miles. |
|---|---|
| Exterior diameter of exterior ring . . . . | 176,418 |
| Interior ditto ditto . . . . | 155,272 |
| Exterior diameter of interior ring . . . . | 151,690 |
| Interior ditto ditto . . . . | 117,339 |
| Equatorial diameter of the body of the planet | 79,160 |
| Interval between the planet and interior ring | 19,090 |
| Interval of the rings . . . . . . . . . | 1,791 |
| Thickness of the rings not exceeding . . . | 100 |

Some observers have noticed, that not only does the entire ring appear divided into *two*, but the outer one is likewise subdivided into *several* concentric rings; this, however, has not been confirmed by Herschel and Struve, who have examined it with the finest telescopes ever constructed. The late Captain Kater, about the year 1825, examined this planet very carefully, and noticed the apparent division of the *outer* ring into several circles, as represented in the frontispiece. It seems that this circumstance had been noticed many years before by Mr. Short; and it had been considered as first settled by the elder Herschel, that there were altogether *two* rings; but, according to Kater's report, he saw, in 1825, not only the two rings, but the outer ring appeared to be divided into two parts by a strong black line, as at fig. 1, and each part to be subdivided into at least two others by fainter black lines, as at fig. 3. A drawing made by another person of this appearance is given at fig. 2. Great doubt has been expressed relative to the fact of the outer ring being thus subdivided. Continued observation was interrupted at the time by the ring disappearing, in consequence of the earth coming into its plane: but the subject will probably not be lost sight of by those who have the best means for observation; and, as the ring is now again expanding to view, the opportunity is afforded for deciding whether the effects noticed by Kater arose from an optical delusion, or corresponded with the phenomena of the belts and zones, which cross the bodies of Jupiter and Saturn.

Some astronomers have imagined these rings to be a vast assemblage of satellites. They certainly serve the purpose of many thousand satellites, and, together with the seven acknowledged moons, probably make up the deficiency in the solar rays coming from such an extreme distance.

Seven satellites, or moons, have been discovered to pass in orbits round the planet Saturn. Two of these moons, the nearest to the body of the planet, were discovered by Herschel with his great telescope. The most distant of the satellites is much the largest, and the next is a very conspicuous object with a good telescope; the next three are very minute, and cannot be seen without very good telescopes, while the two innermost have never been seen, except with the most powerful and finished instruments made by man.

But, however useful these moons and rings may be to the inhabitants of Saturn, they do not, as the moons of Jupiter, answer any directly useful purpose to the inhabitants of the earth. Their great distance, and the consequent difficulty of seeing them, render them nearly useless, with reference to the longitude. We leave them, therefore, to act their part as Providence has appointed them, though we cannot but gaze upon and think of them, with astonishment and admiration of the all-surrounding power of the Almighty.

> One *Moon* on us reflects its cheerful light;
> There, seven attendants brighten up the night;
> Here, the blue firmament bedecked with stars;
> There, over head a lucid *arch* appears.

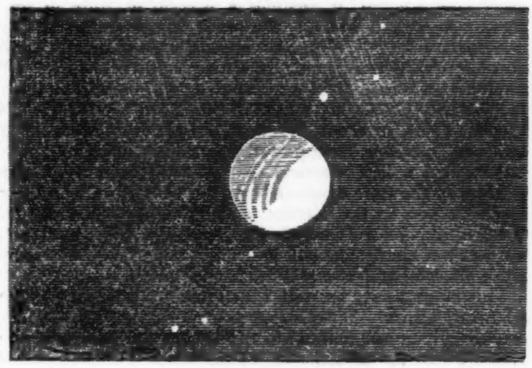
The ring revolves round the planet in about 10 hours and 32 minutes, and in the same plane; which rapidity of revolution gives it a centrifugal force, which keeps it at its due distance in equilibrium.

## URANUS.

> From *Earth*, how large, how strong, the Sun's bright ball!
> But seen from *thence*, how languid and how small!
> When the keen north, with all its fury blows,
> Congeals the floods, and forms the fleecy snows,
> 'Tis heat intense to what can there be known;
> Warmer *our* poles than is *its* burning zone:
> Who there inhabit, must have other powers,
> Juices, and veins, and sense, and life, than ours.

THIS is the last and remotest planet in the solar system, as at present known. It is distant from the Sun the enormous quantity of 1800 millions of miles, being about 19 times further from the Sun than the Earth is; he is about 35,112 miles in diameter, and revolves round the Sun in about 83 years and 150 days; this is the year of Uranus. His Summer half-year, therefore, is upwards of 41 of our years, and his Winter half-year equally long. The surface of the Sun appears from this planet not above $\frac{1}{400}$th of that which it appears to the Earth; the light and heat received by Uranus are, therefore, smaller in the same proportion. Hence, it is quite impossible that any such a fluid as water could exist in that planet, for all would be frozen, and no inhabitants, constituted as the inhabitants of the Earth are, could exist on its surface. Its light from the Sun has been estimated at about the quantity which would be afforded by 240 of our full moons

Fig. 41.



THE PLANET URANUS.

This planet was discovered by Sir W. Herschel, at Bath, on the 13th of March, 1781, by means of the magnificent reflecting telescope constructed by himself, which was 40 feet long. The first circumstance which led him to think that it was a *planet*, and not a fixed star, was that, although it appeared like a star of the seventh magnitude to the naked eye, yet it appeared as one of the first magnitude when seen through his telescope. Now one consequence of the immeasurable distances of the fixed stars is, that they do not appear larger when viewed through a telescope than when seen with the eye, the only difference being an increase of brilliancy. From the circumstance, therefore, of its increased magnitude, Herschel concluded that this celestial body was not a fixed star but a comet; subsequently, however, he arrived at the conclusion, that it was a planet moving round the Sun: to this conclusion he was led by observing its continued proximity to the ecliptic, and its motion among the fixed stars from west to east.

This planet subtends an angle of about 4″, which never appears to vary, owing to the comparative smallness of our orbit. Its disk appears uniformly illuminated, and without rings, belts, or spots. Its bulk is however 80 times that of the Earth, and is supposed to be not quite so dense as water. The orbit of this planet is inclined at an angle of 46′ to the ecliptic.

It is just possible to see this planet with the naked eye on a fine clear evening, when the moon is absent, but it has rarely been noticed without the telescope, when it appears of a bluish white colour. It is said to have been seen before, but to have been regarded as a *fixed star*. Tycho Brahé, we are told, set it down in his catalogue of the fixed stars, as also did Professor Meyer, of Gottingen, in the year 1756. When discovered to be a planet, Herschel dignified it with the name of the *Georgium Sidus*, or *Georgian star*, in honour of his royal patron, George the Third, and by this name it is known in the Nautical Almanack. Foreign astronomers call it *Herschel*, from the name of its discoverer; but the Royal Academy of Prussia, and some others, called it *Uranus*, by which name it is now usually known.

At different times Herschel discovered six satellites moving round this planet, for the same purpose probably as those of Jupiter and Saturn move round those bodies; but these satellites are distinguishable only by the highest telescopic means afforded by art. Two were easily marked out by Sir W. Herschel, but the existence of the others depended for a very long time only on his testimony; these,

together with the two innermost moons of Saturn, are the most difficult objects in the solar system to get a sight of. It is considered to be a very remarkable fact, that the planes of the orbits of the satellites of Uranus are nearly perpendicular to the ecliptic, and that their motions in these orbits are *retrograde*, or from east to west, which is contrary to the order of the signs; but, owing to the very great difficulty of observing these attendant bodies, we have not any decided knowledge respecting their masses and motions.

The discovery of this planet and his satellites was one of the triumphs of the Reflecting Telescope, thus beautifully alluded to by the poet:—

> Delighted Herschel, with reflected light,
> Pursues his radiant journey through the night;
> Detects new guards, that roll their orbs afar,
> In lucid ringlets round the Georgian star.—Darwin.

---

There are some circumstances connected with the planets, as a system, to which we must here allude. When speaking of the attraction of gravitation*, we stated that each body attracts others in proportion to its mass or quantity of matter. Now one consequence of this is, that a given bulk of any substance would weigh differently at the surfaces of the different planets: that planet which is larger, will attract a body which is upon its surface, towards the centre, with more force than a planet which is smaller; and it is this attraction from the surface towards the centre which constitutes the whole of what we mean by *weight;* consequently, a given mass of matter will weigh more on a large planet than on a small one, supposing the density to remain the same: but, as we have already seen that the densities of the planets vary, the force of their relative attractions must be estimated by the increased or diminished density of the mass, as well as by the actual extent or diminution of size.

There has been noticed a remarkable ratio between the distances of the planets from the Sun. As we shall have to speak of the *power* of a number, we may as well here state that it means a *number multiplied by itself* one or more times. Thus $2^3$ means that 2 is to be multiplied into itself twice, or that three 2s are to be multiplied together. If now we call the mean distance of the Earth from the Sun 10, then the mean distances of the other planets are nearly as here follow:—

| | | | |
|---|---|---|---|
| Mercury's distance | - - - - - - - - - - - | = | 4 |
| Venus's „ | $= 4 + 3$ | = | 7 |
| Earth's „ | $= 4 + \overline{3 \times 2}$ | = | 10 |
| Mars's „ | $= 4 + \overline{3 \times 2^2}$ | = | 16 |
| Asteroids' „ | $= 4 + \overline{3 \times 2^3}$ | = | 28 |
| Jupiter's „ | $= 4 + \overline{3 \times 2^4}$ | = | 52 |
| Saturn's „ | $= 4 + \overline{3 \times 2^5}$ | = | 100 |
| Herschel's „ | $= 4 + \overline{3 \times 2^6}$ | = | 196 |

Now we must observe that this tabular law was formed by Professor Bode of Berlin, in the year 1772, before the discovery of the Asteroids and Uranus; and that the void occurring between Mars and Jupiter led several German astronomers to suspect the existence of a planet in that point of space; which surmises received a confirmation by the discovery of the four ultra-zodiacal planets at the beginning of this century; while the law itself had been further confirmed by the discovery of Uranus, as a planet, many years before.

As a curious but faithful illustration of the proportional sizes and distances of the planets, referred to the Sun, we quote the following from Sir J. Herschel.

"Choose any well levelled field or bowling-green. On it place a globe, two feet in diameter; this will represent the Sun; Mercury will be represented by a grain of mustard seed, on the circumference of a circle 164 feet in diameter for its orbit; Venus a pea, on a circle 284 feet in diameter; the Earth also a pea, on a circle of 430 feet; Mars a rather large pin's head, on a circle of 654 feet; Juno, Ceres, Vesta, and Pallas, grains of sand, in orbits of from 1000 to 1200 feet; Jupiter a moderate-sized orange in a circle nearly half a mile across; Saturn a small orange, on a circle of four-fifths of a mile; and Uranus a full-sized cherry, or small plum, upon the circumference of a circle more than a mile and a half in diameter."

* See *Saturday Magazine*, Vol. XII., p. 126.

But when the student of Astronomy shall have come to form a just estimate of the extent of the Solar system, and the magnitude of its component masses, he will yet refer all the members of it, together with the other celestial bodies, to the great concave sphere of the heavens, on which he will trace their various paths, real and apparent. Hence we arrive at the motion and uses of the Celestial Globe; on which the fixed stars are laid down in their several constellations, and by which the course of the sun, and the paths of the moon and planets among the stars may be readily and conveniently traced.

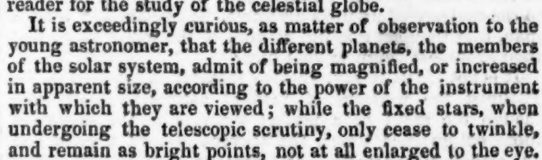
For this purpose the figure at the foot of the present article furnishes the rudiments of the celestial globe; for, as when a person uses this globe, he must fancy himself placed at its centre, so when we direct our attention to the great circles of the heavens, by means of which we estimate the positions and motions of the heavenly bodies, we consider the earth as the central point, as shown in the figure. The axis of the earth being produced both ways, meets the surface of the great sphere of the heavens, at P and Q. These are the poles of the heavens, about which the stars have their apparent or diurnal paths, at right angles to the terrestrial axis, as is seen in the motion of the star at S. If the earth's equator, E C, be carried out to the heavens, the great circle thus formed, Æ Q, is the equinoctial. The *declination* circles are those which have their centre at the centre of the earth, and which are at right angles to the equinoctial; such as P S M. The use of these circles is to determine the situation of a star, &c.; as the latitude of a place on the earth's surface is reckoned on a meridian. This is the computation for north or south; and as on the terrestrial globe it is necessary to know the east or west distance from a meridian, so, on the celestial globe, this is noted from the first point of Aries, thus marked, ♈. This computation goes on eastward round the globe, and is called the star's *right ascension.*

Again, let O be a spot on the Earth's surface, then Z is its zenith; the nadir being opposite, on the other side. Again, let N B S A be the horizon of O; then N and S are the north and south points, and A and B the east and west points. A circle Z S K drawn through a star S from the zenith to the horizon is the azimuth circle of the star, K S is its altitude, Z S its zenith distance, and K N its azimuth.

A consideration of these few particulars will prepare the reader for the study of the celestial globe.

It is exceedingly curious, as matter of observation to the young astronomer, that the different planets, the members of the solar system, admit of being magnified, or increased in apparent size, according to the power of the instrument with which they are viewed; while the fixed stars, when undergoing the telescopic scrutiny, only cease to twinkle, and remain as bright points, not at all enlarged to the eye. These are perhaps the only objects in creation, as far as the range of man exists, which, as to apparent size, are unacted upon to human vision by a combination of lenses. In the cases of other objects, when viewed, the apparent size decreases as the distance increases, and *vice versâ:*—and the use of the telescope is, by bringing the light thrown from the body to a focus, to enable us to see that body under a larger angle. In the following figure, it is clear that the tree, A B, will appear to an observer at E of the same size as the tree, C D, because both subtend the same angle; whereas, the former tree is much smaller than the latter, but stands much nearer to the observer. Now, if both these trees stood at the same distance from the observer at E, yet, if the tree, A B, were observed through a telescope of a certain power, it might be made to appear of the same size as the tree, C D. Hence we may infer that the sun and planets, if removed away to the space occupied by the fixed stars, would appear, if they appeared at all, only as luminous points. In fact, as each fixed star is deemed to be itself the centre of a system of planets, so our sun is, by parity of reasoning, supposed to be only one of those celestial bodies, which we call *fixed stars.*

Fig. 42.




Some of these fixed stars have, as we shall hereafter notice, different colours apparently inherent in themselves.

It is curious to consider whether our sun may not likewise appear as a coloured star, in those regions of the heavens where the fixed stars are situated. Herschel seems to think that the sun must appear to the other fixed stars as one of the *nebulous*, or cloudy stars; that is, those which are too small, or too remote, to be viewed otherwise than dimly. The cause which leads Herschel to form this opinion is the consideration of the phenomenon, called the *zodiacal light;* thus termed because it issues from the zodiac, in the middle of which is the sun's path. This light may be seen any very clear evening, soon after sunset, about the months of April or May; or at the opposite season before sunrise, as a cone of light, extending from the horizon obliquely upwards, and following the course of the sun's path. It is faint and ill defined in this climate, though better seen in tropical countries; but it cannot be mistaken for any atmospheric meteor, or aurora borealis. It seems to be of the nature of a thin atmosphere, surrounding the sun, and extending at least beyond the orbit of Mercury, and even of Venus; and it may be conjectured to be no other than the denser part of that medium, which, as we have reason to believe, resists the motions of comets, and which we shall speak of more fully in its proper place. But we cannot be said to know much more about the zodiacal light, than that it is somewhat similar in appearance to the milky way, of which we shall speak in our next paper, and that it is connected with the rotation of the sun on its axis.

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Thus have we taken a survey of that part of space which is occupied by the Solar System; the grandeur of which we may make an abstract of, by referring to the language of Chalmers, in his Discourse, entitled "A Sketch of Modern Astronomy."

The Psalmist takes a still loftier flight. He leaves the world, and lifts his imagination to that mighty expanse which spreads above it and around it. He wings his way through space, and wanders in thought over its immeasurable regions. Instead of a dark and unpeopled solitude, he sees it crowded with splendour, and filled with the energy of the Divine presence. Creation rises in its immensity before him; and the world, with all which it inherits, shrinks into littleness at a contemplation so vast and so overpowering. He wonders that he is not overlooked amid the grandeur and the variety which are on every side of him; and, passing upward from the majesty of nature to the majesty of nature's architect, he exclaims, "what is man, that thou art mindful of him, or the son of man, that thou shouldest deign to visit him?"

It is not for us to say, whether inspiration revealed to the Psalmist the wonders of modern astronomy; but even though the mind be a perfect stranger to the science of these enlightened times, the heavens present a great and an elevating spectacle,—an immense concave, reposing upon the circular boundary of the world, and the innumerable lights which are suspended from on high, moving with solemn regularity along its surface. It seems to have been at night that the piety of the Psalmist was awakened by this contemplation, when the moon and the stars were visible, and not when the sun had risen in his strength, and thrown a splendour around him, which bore down and eclipsed all the lesser glories of the firmament. And there is much in the scenery of a nocturnal sky, to lift the soul to pious contemplation. That moon, and these stars, what are they? They are detached from the world, and they lift us above it. We feel withdrawn from the earth, and rise in lofty abstraction from this little theatre of human passions and human anxieties. The mind abandons itself to reverie, and is transferred, in the ecstasy of its thoughts, to distant and unexplored regions. It sees nature in the simplicity of her great elements, and it sees the God of Nature invested with the high attributes of wisdom and majesty.

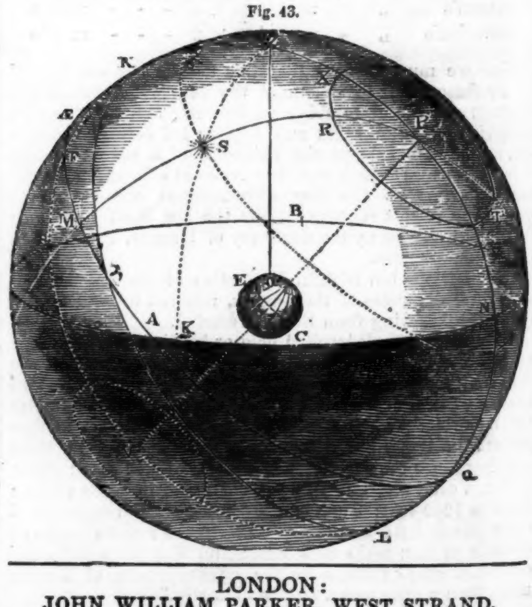
But what can these lights be? The curiosity of the human mind is insatiable, and the mechanism of these wonderful heavens, has, in all ages, been its subject and its employment. It has been reserved for these latter times to to resolve this great and interesting question. The sublimest powers of philosophy have been called to the exercise, and astronomy may now be looked upon, as the most certain, and best established of the sciences

We also know, that every visible object appears less in magnitude as it recedes from the eye. The lofty vessel, as it retires from the coast, shrinks into littleness, and at last appears in the form of a small speck on the verge of the horizon. The eagle, with its expanded wings, is a noble object: but when it takes its flight into the upper regions of the air, it becomes less to the eye, and is seen like a dark spot, upon the vault of heaven. The same is true of all magnitude. "The heavenly bodies appear small to the eye of an inhabitant of this earth only from the immensity of their distance. When we talk of hundreds of millions of miles, it is not to be listened to as incredible. For remember that we are talking of those bodies which are scattered over the immensity of space, and that space knows no termination. The conception is great and difficult, but the truth is unquestionable. By a process of measurement which it is unnecessary at present to explain, we have ascertained first the distance, and then the magnitude, of some of those bodies which roll in the firmament; that the sun which presents itself to the eye under so diminutive a form, is really a globe, exceeding, by many thousands of times, the dimensions of the earth we inhabit; that the moon itself has the magnitude of a world; and that even a few of those stars which appear like so many lucid points to the unassisted eye of the observer expand into large circles upon the application of the telescope; and are some of them much larger than the ball which we tread upon, and to which we proudly apply the denomination of the universe."

"Did the discoveries of science stop here, we have enough to justify the exclamation of the Psalmist, 'What is man that thou art mindful of him; or the son of man that thou shouldest deign to visit him?' They widen the empire of creation far beyond the limits which were formerly assigned to it. They give us to see that yon sun, throned in the centre of his planetary system, gives light and warmth, and the vicissitude of seasons, to an extent of surface several hundred times greater than that of the earth which we inhabit. They lay open to us a number of worlds, rolling in their respective circles around this vast luminary; and prove that the ball which we tread upon, with all its mighty burden of oceans and continents, instead of being distinguished from the others, is among the least of them; and from some of the more distant planets, would not occupy a visible point in the concave of their firmament. They let us know, that though this mighty earth, with all its myriads of people, were to sink into annihilation, there are some worlds, where an event so awful to us, would be unnoticed and unknown, and otners where it would be nothing more than the disappearance of a little star which had ceased from its twinkling. We should feel a sentiment of modesty at this just but humiliating representation. We should learn not to look on our earth as the universe of God, but one paltry and insignificant portion of it; that it is only one of the many mansions which the Supreme Being has created for the accommodation of His worshippers, and only one of the many worlds rolling in that flood of light, which the sun pours around him to the outer limits of the planetary system."

In our next and concluding article we shall take up the subject of *comets, fixed stars, nebulæ,* &c.

Fig. 43.

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